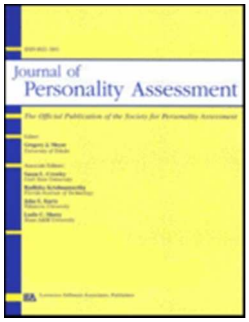
Mirroring Activity in the Brain and Movement Determinant in the Rorschach Test



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Abstract

Human movement (M) responses to the Rorschach are related to cognitive sophistication, creativity, and empathy. Recent studies also link Ms to EEG-mu suppression, an index of mirroring activity in the brain. In this article, we further investigate the link between Ms and mu suppression, by testing some clinical interpretative distinctions. Previously collected EEG data recorded during the administration of the Rorschach were re-analyzed. We hypothesized that (1) among several responses investigated, only M would be associated with mu suppression and (2) Ms with active movement, ordinary form quality, or whole human figures would be most strongly associated with mu suppression. Hypothesis 1 was fully confirmed, thus supporting that the traditional interpretation of M has a neurobiological foundation. Hypothesis 2 was partially confirmed, i.e., active Ms were associated with mu suppression more strongly than passive Ms ($p<.05$), but no other significant differences emerged. Clinical implications are discussed.

Keywords: electroencephalography, human movement, empathy, mentalization, mirror neurons, Rorschach

Mirroring Activity in the Brain and Movement Determinant in the Rorschach Test

In forming responses to the Rorschach test (Rorschach, 1921), respondents select among a variety of distinct perceptual features suggested by the inkblot stimuli. Such features are called determinants and help to identify or determine the specific representation or imagery in the response. They include form (contour) of the blot (e.g., "it looks like a person because of the shape"), color (e.g., "the shape and the color make it look like a red hat"), and shading (e.g., "a person surrounded by smoke because of the shading there"). All these features are pulled directly from the actual characteristics of the stimuli that indeed have different ambiguous shapes and are pictured with various colors and achromatic nuances. There is a fourth, atypical class of determinants, referred to as "movement." Rorschach stimuli are static images and obviously do not move. Unlike other determinant classes, which are actually contained in the figure, perceived movement (e.g., "two people dancing together") is added to the stimulus field, presumably, as a product of ideational and imagined activity of the respondent as he or she "experiences" the sensation that the seen object is moving. Since the publication of Hermann Rorschach's monograph (1921), human movement (*M*) responses to the test are almost unanimously considered as one of the best sources of information about personality dynamics. For example, Mayman (1977) argued that *M* responses are "the richest, most revealing, consistently more interesting responses which occur on the Rorschach test" (p. 230); and Piotrowski (1977) said that they "provide, more than any other single test component, specific and significant information about the individual's role in the interhuman relationships that matter to him" (p.189). This additional interpretive value attributed to *M* responses by outstanding authors of the century-long history of the Rorschach test might be one of the reasons why this determinant category has been retained in all the Rorschach systems despite the major changes that have occurred from

one system to another (e.g., Beck, 1944; Exner, 1969, 2003; Klopfer & Kelley 1944; Meyer, Viglione, Mihura, Erard, & Erdberg, 2011; Piotrowski, 1957).

Human Movement in the Rorschach Test

Three types of movement responses occur in the Rorschach test, human movement (M), animal movement (FM), and inanimate object movement (m). Rorschach paid particular attention to the human movement. He believed that when producing a human movement response, individuals identify themselves with the human figure seen in the stimulus, as if they were performing the same movement (Malmgren, 2000; Rorschach, 1921). This process was referred to as "kinesthesia"[1]. Importantly, Rorschach believed that such kinesthetic identification would only be possible when the response object is a human being in movement (e.g., "a woman dancing with hands up"). That is, the kinesthetic identification does not occur when the response object is an animal making a movement confined to the animal species (e.g. "a bird flying in the air"). It would also not occur when the response involves an inanimate object in movement (e.g., "smoke rising up"). Historically, only Beck (1944) and to some degree Rapaport, Gill, and Schafer (1946) defended Rorschach's position and did not score non-human movement. Other systems, including the Comprehensive System (CS, Exner, 2003), distinguished between the three types of movement responses and argued that they corresponded to distinct psychological operations and interpretations.

All of the Rorschach systematizers have conceived *M* responses as indices of higher level cognitive functioning, although from different perspectives, and with some distinctions. In fact, in order to recognize a static human figure as a person who is doing something, it is likely some sort of representation or even a feeling of movement should be present in the mind of the subject who is looking at the card. Stated differently, the subject likely invokes higher-level cognitive processes, possibly imagination, creative thinking, identification with another human being, or a perspective-taking approach, etc. (Exner, 1969). In the Klopfer

system (Klopfer & Kelley, 1944), *M* serves as the basic indicator of a well-functioning personality. *M* bridges the gap between inner resources of drive and fantasy and the outward orientation of reality testing and object relations or interpersonal schema. It incorporates creative capacities, the acceptance of one's own self and inner promptings, and the richness of the inner life. According to Beck (1944), *M*s represent those strong emotions that the individual is able to contain internally, thereby converting them to adaptive and creative processes. Piotrowski (1957) expressed a more articulated view of *M* responses, suggesting that they always imply interest in people, awareness of the self, concern with the future, and mostly the subject's "role-in-life," which reflect basic characteristics of the personality. According to him, *M*s stand for the most individual and integrated strivings that dominate the individual's life and indicate traits stabilizing the relation between the individual and his environment. They are potential actions, rather than actual actions; initial stages of actions at a very low level of intensity. From the perspective of the psychodynamic model of Ego Psychology, Rapaport et al. (1946) claimed that *M* responses indicate the ability to delay the individual's emotional response, the readiness to make anticipations, and the flexibility of perceptual and associative processes in general. Borrowing from all these traditions, Exner (2003) focused on the cognitive aspects of the *M* response and noted that it involves the elements of reasoning, imagination, and higher forms of conceptualization; a form of delay from yielding to more spontaneous responses to the environment during which time an active and deliberate form of directing one's inner life occurs. He gave less emphasis to the social cognition[2] component, although he did acknowledge the importance of the identification mechanism upon which the *M* response is presumably based.

Traditionally, and particularly in the CS, *M* responses delivered in association with perceptual distortions (Form Quality *minus, FQ-*) and/or embellishment of various kinds (*Special Scores*) are considered as particularly likely to reveal underlying problematic aspects

of personality, because individuals are putting in the blots idiosyncratic features that go beyond the stimulus properties (Meltzoff, Singer, & Korchin, 1953; Weiner, 2003). *M* responses characterized by *FQ-* (i.e., perceptual distortion), for example, are thought to reflect impaired representations of a human being, and the lack of realistic understanding of others' thoughts, feelings, and intentions. The specific type of movement described in the *M* response, is believed to reveal key information as well. *M* responses characterized by active (e.g., "a person lifting an object") versus passive (e.g., "a woman being lifted up by a U.F.O.") movements, for instance, reflect very different attitudes in terms of propensity for passive versus active imagery involving people (Exner, 2003). This is also believed to extend to the real life attitudes towards interpersonal relationships. In fact, a predominance of active *M* responses has been found among women employed as strippers, in contrast to a relative predominance of passive *M* responses among women employed as models (Young & Wagner, 1993). Another important distinction, finally, is the difference between *M* responses associated with whole human figures (pure *H*) and *M* responses associated with non-whole human figures (non-pure *H*). Indeed, pure *H* is the only content coding category used for responses that include whole real people, whereas human details and human-like figures refer to partial human body and fictional people. Whole human contents are therefore thought to be chosen by those whose self-image is based more on identifications with real persons while non-whole human figures are likely to be selected by those whose self-image is based more on imagination or internal representations that coincide less with reality. Thus, *M* responses associated with pure *H* are believed to be more desirable and optimal kinds of responses as compared to *M* responses associated with non-pure *H*.

In line with most of the theories described above, a wide body of empirical research has shown that *M* responses are associated consistently with ideational and social processes including field independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), effective

interpersonal relations and behaviors (Exner, 2003), ego strength and introversion (Greenwald, 1991; Hix et al., 1994), ability to cognitively process emotions (Porcelli & Meyer, 2002; Porcelli & Mihura, 2010; Ruhe & Lynn, 1987), creativity (Ferracuti, Cannoni, Burla, & Lazzari, 1999), dream recall (Orlinsky, 1966), and intelligence (Gallucci, 1989; Wood, Krishnamurthy, & Archer, 2003). *M* has also been associated with sensory deprivation (Bendick & Klopfer, 1964), electromyography-based muscle potentials (Steele & Kahn, 1969), ability to discriminate florid and withdrawn schizophrenics from healthy subjects (Di Nuovo, Laicardi, & Tobino, 1988), and symptom improvement after psychotherapy (Exner & Andronikof-Sanglade, 1992; Weiner & Exner, 1991).

Synthesizing the available empirical research leads to the conclusion that the *M* responses may be considered indices of higher cognitive functioning (because *M* involves the integration of different perceptual features and individual psychological involvement), ability to imagine (because the actual stimuli do not move), and empathy (because of the implied ability to identify with a human being) (Exner, 2003; Exner & Erdberg, 2005). Ms are strongly linked to the individual's ability and tendency to evoke an internal experience of movement from an ambiguous stimulus and to involve this experience of movement in the perceptual processing of static pictures. The psychological process eliciting *M* responses resembles theoretical constructs such as *Einfühlung* (a German term meaning literally "feeling-into" which has been used in the experience of art indicating the immediate physical responses generated in the observer by the exposure to art painting), empathy (the ability to put oneself in the place of another in terms of actions, sensations, and emotions), and also mentalization (the cognitive mechanism that allows one to ascribe goals and intentions to others). This process is consistent with main theoretical concepts and models in the field of psychological functioning, as the psychodynamic mechanism of identification (Gabbard, 2005) and the construct of vicarious learning (Bandura & Walters, 1964). Also, the human

capacity to pre-rationally make sense of the actions, emotions, and sensations of others depends on 'embodied simulation,' a functional mechanism through which the actions, emotions, or sensations we see activate our own internal representations of the body states that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Freedberg & Gallese, 2007). A growing body of studies published in the last two decades supports the 'shared manifold hypothesis' that the brain substrate linking the bridge between embodied simulation and *Einfühlung*, empathy, and mentalization may be constituted by the mirror neuron system (MNS, Gallese, 2001; Hurley, 2008).

The Mirror Neuron System (MNS)

Mirror neurons are cortical brain cells that fire during both the execution and the observation of motor behavior. They were discovered during single cell recording of the ventral premotor cortex (area F5) in macaque monkeys that either performed an action or observed the same action performed by another monkey or an experimenter (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). However, mirror neurons were not activated when a monkey merely observed a static object or when it observed a screen with several points moving randomly. This line of research supported the notion that the MNS subserves observation-execution matching system, a possible mechanism by which action recognition, action understanding, and imitation can be achieved (Gallese et al., 1996; Rizzolatti, Fogassi, & Gallese, 2001; Umiltà et al., 2001).

Single-unit recording is not typically performed in the human brain (although see Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). However, indirect population-level measures support the existence of a functional analogous system to macaque MNS in the human inferior frontal gyrus (IFG) (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni et

al., 1999) through transcortical magnetic stimulation (TMS, Fadiga et al., 1995; Maeda, Kleiner-Fisman, & Pascual-Leone, 2002; Strafella & Paus, 2000), positron emission tomography (PET) (Parsons et al., 1995), functional magnetic resonance imaging (fMRI) (Buccino et al., 2004; Grézes, Armony, Rowe, & Passingham, 2003; Iacoboni et al.,1999), and electroencephalography (EEG) (Cochin, Barthlemy, Lejeune, Roux, & Martineau, 1998; Muthukumaraswamy & Johnson, 2004; Oberman, McCleery, Ramachandran, & Pineda, 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda, Allison, & Vankov, 2000; Pizzamiglio et al., 2005; Rizzolatti et al., 2001). Further, data are consistent with the idea that the frontal MNS in humans may be part of a broader network of brain regions including the inferior parietal lobule (Buccino et al., 2001; Parsons et al., 1995), the superior temporal sulcus (Iacoboni et al., 2001), sensorimotor cortex (Pineda, 2008), and regions of the limbic system (Morrison, Lloyd, di Pellegrino, & Roberts, 2004; Singer et al., 2004; Wicker, Keysers, Plailly, Gallese, & Rizzolatti, 2003). This broader network suggests that the MNS may play a more sophisticated role than pure imitation.

In humans it is speculated that mirror neurons represent not only the physical aspects of an action but also the underlying intentions, thoughts, and feelings that motivated that action. Said differently, perhaps they provide the neural basis for unique human social skills such as empathy, theory of mind, and facial emotion processing (Gallese, 2001, 2006; Gallese & Goldman, 1998; Pelphrey & Morris, 2006; Rizzolatti, Fabbri-Destro, & Cattaneo, 2009; Uddin, Iacoboni, Lange, & Keenan, 2007) that allow effective social cognitive processes and interactions. Crucial to our work are recent investigations with non-clinical populations of the proposed link between the MNS and social cognitive functions such as empathy (Gazzola, Aziz-Zadeh, & Keysers, 2006; Kaplan & Iacoboni, 2006; Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008) and facial emotion processing (Enticott, Johnston, Herring, Hoy, & Fitzgerald, 2008; Sato & Yoshikawa, 2007; Wicker et al., 2003).

An intriguing issue related to MNS activity is the role played by the nature of the perceptual stimuli. The visual feature that activates mirror neurons is the observation of a significant interaction between the agent of the action (e.g., seeing a hand grasping) and the object being the target of it (e.g., a tea cup). Mirror neurons in monkeys typically do not respond to the observation either of a hand merely miming an action or an object alone, even when the object is of interest (e.g., food). In other words, mirror neurons are part of a neural matching system that allows the observer, during action observation, to place her or himself in the same "internal" situation as when actively executing the same action. An important experiment showed that the MNS in monkeys responds when the final part of an action, most crucial in triggering the response in full vision, was hidden to the observer, i.e., when the intention of the hand gesture could only be inferred (Umiltà et al., 2001). Similar results emerged when the actual stimuli were not moving but rather static images from which dynamic information were extracted (implied motion). For example, the medial temporal/medial superior temporal cortex (MT/MST complex) is thought to activate during the visual experience of real (as in movies) or illusory motion, namely when the observer can infer the position of an object in a subsequent moment in time without seeing the actual movement, such as seeing two photographs of an athlete before and after heaving the shot put (Kourtzi & Kanwisher, 2000). Similarly, a TMS study indicated that the MNS is responsive when dynamic information about body actions is inferred from static pictures of body postures (photographs of pincer grips) (Urgesi, Moro, Candidi, & Aglioti, 2006).

Assessment of the MNS Activity with the EEG

Previous studies (Cochin et al., 1998; Oberman et al., 2005, Oberman, McCleery et al., 2007; Oberman, Pineda et al., 2007; Pineda et al., 2000) have linked activity in the human MNS with activity in the EEG mu frequency band recorded over sensorimotor cortex. At rest, these sensorimotor neurons spontaneously fire in synchrony (Gastaut, 1952), leading to large

amplitude EEG oscillations in the 8–13 Hz (mu) frequency band. When subjects perform an action, these neurons fire asynchronously, reflecting greater levels of active processing during motor movement and observation, and thereby decreasing the power of the mu-band EEG oscillations (Pfurtscheller, Neuper, Andrew, & Edlinger, 1997). Over the past 50 years there have been several theories relevant to the function of the mu rhythm (for a review, see Pineda, 2005). Most recently, results of several studies have uncovered various properties of mu suppression that directly link it to the frontal mirror neuron system. First, mu power recorded from electrodes over sensorimotor cortex (scalp locations C3 and C4; Figure 1) is reduced by self-initiated movement and observed movement (Babiloni et al., 1999; Cochin et al., 1998; Gastaut, 1952; Oztop & Arbib, 2002; Pineda et al., 2000). Importantly, similar to mirror neuron activity, the mu wave does not respond to nonbiological directional motion such as bouncing balls (Oberman et al., 2005). Furthermore, analogous to previous fMRI studies of the MNS (Buccino et al., 2001), the presence of a target object increases mu wave suppression as compared to pantomimed actions (Muthukumaraswamy & Johnson, 2004; Muthukumaraswamy, Johnson, & McNair, 2004).

Since the mu rhythm is generated by activity in sensorimotor areas (Gastaut, 1952), and mirror neurons are located in premotor cortex, it has been hypothesized that the mu rhythm may specifically index downstream modulation of primary sensorimotor processing by mirror neuron activity (Muthukumaraswamy & Johnson, 2004; Pineda, 2005).

Rorschach M Responses and the Mirroring Activity

As stated previously, the brain location of the MNS network indicates that these neurons code not only for specific, actual motor acts performed by the individual or seen in another individual, but, by virtue of being wired to neurons that code for the subsequent motor acts, they facilitate the activity of these downstream neurons. Briefly, mirror neurons predispose the individual to subsequently perform the smooth execution of the intended

action, thus favoring the notion that the MNS mediate action understanding behind the observed motor act (Rizzolatti et al., 2009). For example, mu wave suppression to EEG has been observed in children with autism spectrum disorder when a familiar person performed a deliberate action but not when it was performed by an unfamiliar person (Oberman, Ramachandran, & Pineda, 2008).

The fact that mirror neurons discharge when the subject understands the potential action or the subjective intention to perform an action (i.e., observing not only another individual drinking a glass of beer but also the picture of a human hand close to a glass of beer or even the glass of beer alone) has allowed us to advance the hypothesis that the MNS would be activated also when one imagines a movement in a static picture without the actual movement (for example, see studies linking imagination and EEG alpha/beta activity such as Pfurtscheller et al., 1997). We speculated that such mentalization is very close to what is thought to occur when an individual articulates the *M* response while observing the Rorschach stimuli, namely when actions are mostly generated "internally," within the individual's experience (feeling of motion), and triggered by minimal indirect cues placed "externally," in the actual static picture itself.

In a first study (Giromini, Porcelli, Viglione, Parolin, & Pineda, 2010), EEG data from 15 undergraduate students were collected during baseline and three conditions (experimental, contrast, and control) while they were observing the Rorschach cards on a video screen. In the experimental condition (attribution of human movement), the participants were asked to look at four Rorschach cards: two cards (III and VII) with the highest frequency of *M* responses and two cards (V and VI) with the lowest frequency of *M* responses in the Rorschach CS reference database (Exner & Erdberg, 2005). While viewing the card, participants had to think of the answer to the question "What might this be?" Because of the technical constraints determined by the EEG procedure, they were required to look at the

cards first and only later to verbalize their responses, thus avoiding uncontrolled artifacts in the EEG recording. This slightly diverges from the standard Rorschach procedure of having the liberty to immediately describe what one sees. In the contrast condition (identification of human movement), the subjects were asked to observe the four Rorschach cards with suggestions verbally provided by the experimenter during the visual exposure to identify a commonly reported movement response (e.g., "two children doing something together") on the two cards with the highest proportion of human movement attribution, and a different commonly reported response (e.g., "a tree") on the two cards with the lowest proportion of human movement attribution. In the control condition (observation of human movement), the subjects were asked to observe non-ambiguous hand-made drawings specifically created to resemble the Rorschach inkblots shown earlier, two representing a commonly reported human movement response to the related inkblot (e.g., "two children doing something together") and the other two representing a different commonly reported response (e.g., "a tree").

The results show that greater mu wave suppression occurred at C3, Cz, and C4 sites for all the movement conditions when compared to the non-movement conditions; when actions were either strongly suggested by the features of the stimuli (non-ambiguous drawings closely resembling the Rorschach cards in the control condition), by verbal suggestions verbally provided during the visual exposure to the stimuli (Rorschach cards used during the contrast condition), and by the subjective internally generated representation of human movement (Rorschach cards used during the experimental condition). As hypothesized, our data show that mu suppression accompanies the Rorschach *M* responses.

Those findings were limited, however, by the use of only four Rorschach cards and technical issues such as the baseline condition in which subjects had to look at a white card on a computer screen for 25 s without assessing the individual's level of attention to the task.

Conceivably, distraction, free-thinking, and boredom might have affected attention levels later in the exposure period. Therefore, in our second study (Pineda, Giromini, Porcelli, Parolin, & Viglione, 2011) we used a larger sample size (24 undergraduate students), all the ten cards of the standard Rorschach test in the standard Rorschach CS procedure (Exner, 2003), a more appropriate control for baseline attention (participants were asked to engage in a continuous performance task during the 90-s baseline period), and longer data collection periods (600 s of EEG data recording). The results extended our previous findings in two important issues. First, replicating earlier findings in a more ecological way, mu suppression at central sites was greater in association to *M* responses compared to non-*M* responses throughout all the ten Rorschach cards. Second, event-related desynchronization (ERD) analyses showed that, unlike the non-*M* responses, when delivering *M* responses, mu suppression occurred very early, during the first 1-2 s of exposition to the cards and remained so for the entire exposure time. This may suggest that the mirroring phenomenon occurs prior to the conscious decision of the subject to actually deliver an *M*-codable response.

This second study, however, does not fully answer some important questions. First, by focusing only on the *M* response, and not other perceptual experiences or determinants (e.g., animal or inanimate movement responses, shading, etc.), one cannot address the discriminant validity of the association between *M* responses and mirroring activity. In other words, our second study did not rule out that the mu suppression phenomenon could also occur for other Rorschach responses, such as shading, pure form or color responses. Establishing discriminant validity is most important for *M* versus response features that share some perceptual features with *M* but are interpreted differently, such as animal movement responses (*FM*, “a dog eating”), and non-moving human content responses (*m*, “the silhouette of a person”). Such research could test the traditional distinctive interpretation of the *M* response as an index of social cognition.

A second important open question left from our previous studies concerns the relationship between the mu suppression phenomenon and the typology of *M* responses. As reviewed above, some *M* responses are interpreted favorably. *M* responses associated with adequate rather than distorted perceptual elaborations, characterized by active rather than passive movements, and formulated considering whole, real, persons rather than human-like or partial figures are likely to indicate more mature and healthy psychological processes, and are presumably related to superior social cognition abilities. Investigating the relationship between mu suppression and typology of *M* would test these interpretive distinctions.

Aims and Hypotheses of the Study

In the previous reports of our research (Giromini et al., 2010; Pineda et al., 2011), we argued that the association between *M* responses and mirroring activity supports the traditional interpretation of *M* responses, in that the MNS is thought to be a neurological correlate of social cognition. In this article, we aim at further relating these neurophysiological findings to the standard assessment practice, by analyzing different kinds of Rorschach responses, and testing a number of clinical interpretative distinctions.

Based on considerations and findings from earlier investigations, in this paper we further hypothesize that:

(1) The mu suppression phenomenon only occurs for Rorschach *M* responses because of their association with social cognition and social competence and does not occur for other perceptual experiences or determinants (e.g., animal or inanimate movement responses, shading etc.,) which are not related to social cognition and social competence (Hypothesis 1: "M vs. Other Determinants");

(2) Human movement responses expected to be more strictly related to social cognition and social competence (e.g., adequately perceived human beings in movement) are more strongly associated to mu suppression than human movement responses more related to poor

social skills (e.g., distorted perceptions of human beings in movement) (Hypothesis 2: "Subtypes of M").

To investigate these two hypotheses we re-analyzed the data set published in Pineda et al. (2011).

Method

Participants

As described in Pineda et al. (2011), the sample consisted of 24 undergraduate students (17 women and 7 men) recruited from the Psychology Department's subject pool at the University of California, San Diego (UCSD). Age ranged from 18 to 25 years (M = 20.4, SD = 1.9). All participants received class credits, and gave written consent. The study was approved by the Institutional Review Board at UCSD and was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Procedure

Stimuli were shown on a screen situated at a distance of 96 cm, at a size of 17 x 24 cm, similar to the original Rorschach cards. EEG data were collected during a baseline and an experimental condition. During exposure to the stimuli participants were instructed not to talk or move. The baseline condition consisted of watching a visual white noise for 90 s. To ensure that participants attended to the screen, they were asked to engage in a continuous performance task. Randomly, the screen turned red five times and blue four times, each color change lasting for 1 s, during the 90 s baseline period. Participants were 100% accurate in their ability to count the number of time that the screen turned red.

The experimental condition consisted of asking the participants to look at the ten Rorschach stimuli, one at a time in order, with the instruction to think of what they might be, consistently with the standard instructions of the CS (Exner, 2003). Two experimental sessions were included. During the first experimental session, each Rorschach image was

presented right side up and remained on the computer screen for 30 s. Participants were instructed to continue focusing on their one response for the entire period of EEG recording. At the end of each 30 s exposure, the image was removed from the screen and participants were then asked to verbalize their response to the stimulus. All Rorschach cards were administered during this first experimental session. At the end of this session, participants were asked to repeat the entire task. All Rorschach cards were presented again in the same standard order, with the participants being instructed to think, for each card, of a different response from what they articulated before. Except for this instruction, the second experimental session was identical to the previous one and was scheduled in order to obtain sufficient amounts of clean EEG data.

At the end of the two experimental sessions, a total of 20 responses and 600 s of EEG data (30 s per response) were collected.

EEG Data Acquisition

Data were collected from 13 electrodes embedded in a cap, at the following scalp positions: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, and O2, using the international 10–20 method of electrode placement (see Figure 1). EEG was recorded at a sampling rate of 500 Hz and analyzed using a Neuroscan Synamps system (band pass 0.1–30 Hz). After removing artifacts, the integrated power in the 8–13 Hz range was computed using a Fast Fourier Transform. Mu suppression over sensorimotor cortex (scalp locations C3, Cz and C4) was calculated as the ratio of the power during the experimental condition relative to the power during the baseline condition (Pineda & Hecht 2009; Ulloa & Pineda, 2007). As a common procedure for this type of study (Altschuler et al., 2000; Bernier, Dawson, Webb, & Murias, 2007; Martineau, Cochin, Magne, & Barthelemy, 2008; Oberman et al., 2005, Oberman, McCleery et al., 2007; Oberman, Pineda et al., 2007; Pineda & Hecht, 2009; Ulloa & Pineda, 2007), a ratio was used to control for variability in absolute mu power as a result of

individual differences such as scalp thickness, electrode placement, and impedance, as opposed to differences in brain activity. Since ratio data are inherently non-normal, as a result of lower bounding, a log transform was used for analysis (i.e., the log of the ratio was used). Indeed, a mu suppression index for each scalp location was computed for each card, corresponding to the log ratio of mu power during the observation of the card over the mu power during the baseline. A log ratio of less than zero indicates suppression.

Statistical Analyses

Several analyses were computed to investigate the effect of different response processes underlying various types of Rorschach responses on mu suppression.

Hypothesis 1: M vs. Other Determinants. We anticipated that, because the MNS is thought to be involved in social cognition, the human movement (*M*) responses should be the unique Rorschach response specifically associated with mu suppression unlike other types of responses such as non-moving human content (non-*M H* contents), non-human movement of animals (*FM*) or inanimate objects (*m*), color responses (*C*), shading-achromatic responses (*Y, T, V, C'*), and pure form responses (*F*) (Table 1). Thus, if these hypotheses were true, one should expect that mu suppression would be strongly associated only with human movement (Table 1, Category 1), and not associated with non-moving human content (Table 1, Category 2), non-human movement (Table 1, Category 3) or other important Rorschach determinants (Table 1, Category 4).

To test hypothesis 1, the association between mu suppression and the selected responses (e.g., non-human movement) was analyzed by implementing the same procedure that Pineda et al. (2011) adopted to investigate the association between M responses and mu suppression. Accordingly, the mean mu suppression during the observation of the cards with the selected response was compared to the mean mu suppression to cards without that response. For example, to investigate the relationship of non-human movement responses to

mu suppression, (a) the mean mu suppression during the observation of the cards to which the participants attributed *FM* or *m* responses was compared to (b) the mean mu suppression during the observation of the cards to which participants did not attribute *FM* or *m* responses. The only one exception regards Category 2 of Table 1: given that it is likely that *M* responses occur along with human contents, to avoid confounds this contrast was tested after excluding all *M* responses from the analysis.

This series of analyses aimed at establishing the discriminant validity of the association between *M* responses and mirroring activity.

Hypothesis 2: Subtypes of M. We anticipated that adequately perceived human beings in movement (i.e., *M* with Form Quality ordinary; *M/FQo*), active human movement (*Ma*), and human movement associated with whole human figures (i.e., *M* with pure *H*; *M/PureH*) would be more strongly associated with mu suppression than distorted or unusual perceptions of human beings in movement (i.e., *M* with Form Quality minus or unusual; *M/FQ-/FQu*)[3], passive human movement (*Mp*), and human movement associated with non whole-human figures as animals (*A*) or human details (*Hd*) only or human-like figures or details [*(H)* and *(Hd)*] (*M/NonPureH*). Indeed, *M/FQo*, *Ma*, and *M/PureH* responses are considered to be more adequate or enhanced types of *M* responses – and thus more desirable and optimal – than *M/FQ-/FQu, Mp*, and *M/NonPureH* (see Table 2). To test this hypothesis, mu suppression occurring during *M/FQo*, *Ma*, and *M/PureH* responses was compared, respectively, to that occurring during *M/FQ-/FQu*, *Mp*, and *M/NonPureH*.

Effect size estimates for within-subjects analysis of variance were determined with η^2 using the following standard criteria: small = .01 to .05, medium = .06 to .13, and large = greater than .14 (Kittler, Menard, & Phillips, 2007).

Results

Rorschach response verbalizations were transcribed verbatim and coded according to standard CS rules. Before analyzing the data, three of the authors (L.G., P.P. and L.P.), who are experts well trained in the CS and have been using the CS in clinical and research settings for many years (two of them for more than 10 years), reached 100% agreement for the presence *vs.* the absence of human movement included in the data analyses. Furthermore, intra-class correlations (ICC) for all the other determinants (color, shading, achromatic and pure form determinants) and contents of interest (animal, human, and human-like contents) showed good (ICC > .60) to excellent (ICC > .74) agreement.

Participants who did not produce any response of the type specified in an analysis were excluded from that specific analysis. The number of participants included in each analysis is reported in Table 3.

Hypothesis 1: M vs. Other Determinants

For each contrast, a two-way repeated-measures analysis of variance compared the mean mu suppression using response type (presence vs. absence) and scalp location (C3, Cz, and C4) as within-subject factors (Table 3).

Pineda et al. (2011) reported that a significant main effect was obtained for *M* response (Table 1, Category 1) ($F(1,23) = 18.76$, $p < .001$), with a large effect size ($\eta^2 = .17$). The additional analyses performed for the current study investigated whether other variables were associated with mu suppression as well. The main effect for human contents in the absence of M responses (Table 1, Category 2) approached statistical significance ($F(1,22) = 4.12$, $p = .055$), with a medium effect size ($\eta^2 = .06$). None of the other main effects – i.e., the main effects for non-human movements (Table 1, Category 3), color responses (Table 1, Category 4, first row), shading or achromatic responses (Table 1, Category 4, second row), and pure form responses (Table 1, Category 4, third row) – approached significance.

None of the scalp location main effects were significant. For non-human movements (Table 1, Category 3) the interaction effect (scalp location x response) was significant, $F(2, 46) = 3.88$, $p = .028$, but effect size was very small, $\eta^2 < .01$, and marginal means analyses did not reveal any significant differences, $p \geq .13$. None of the various other interactions was significant.

Hypothesis 1 that *M*s are the unique Rorschach responses specifically associated with mu suppression at central brain sites was therefore supported. This result provides evidence for the discriminant validity of the association between *M* responses and mirroring activity.

Hypothesis 2: Subtypes of M

Similar to the procedure followed to test Hypothesis 1, for each contrast, a two-way repeated-measures analysis of variance compared the mean mu suppression using *M* type (optimal [*M/FQo*, *Ma*, and *M/PureH*] vs. non-optimal [*M/FQ-/FQu, Mp*, and *M/NonPureH*]) and scalp location (C3, Cz, and C4) as within-subject factors.

The comparison between adequately perceived human movement (*M/FQo*) and distorted-unusually perceived human movement (*M/FQ-/FQu*) did not produce significant difference, $F(1,10) = 1.95$, $p = .193$. A significant main effect for response was observed, instead, for the comparison between mu suppression for active (*Ma*) vs. passive (*Mp*) human movement, $F(1,17) = 7.27$, $p = .015$), with a medium to large effect size ($\eta^2 = .13$). Finally, mu suppression for human movement associated with whole human figures (*M/PureH*) did not significantly differ from mu suppression for human movement associated with non-whole human figures (*M/NonPureH*), $F(1,16) = .30$, $p = .593$. Details for these contrasts are found in Table 3, lower part. None of the various scalp main effects or interactions was significant.

Hypothesis 2 that *M* responses associated with variables more closely related to social cognition rather than poor social competence would produce higher mu suppression was only partially confirmed, only for active movement (*Ma*).

Additional Analyses

To rule out the rival hypotheses that findings were due to phenomena like attention or visual processing, rather than to a mirroring activity, the 8–13 Hz frequency band activity from occipital sites was examined as well. Indeed, if findings at the central sites were not due to a mirroring activity effect, but just to a 'global alpha-like desynchronization', then similar patterns at both central and occipital sites would be expected.

The same analyses that led to significant or nearly significant results at central sites were implemented for posterior sites (scalp electrodes O1 and O2). That is, a series of 2 x 2 within-subject repeated measures ANOVAs (site x response) was tested, with the alpha-like suppression at posterior sites being the dependent variable, while the site (O1 vs. O2) and the presence vs. absence of a response (i.e., M, Ma, and Non-M H Content) comprised the factors. In line with the mirroring activity explanation, none of the several main effects nor interactions analyzed were significant.

Discussion

In two previous studies (Giromini et al., 2010; Pineda et al., 2011) we explored the hypothesis that *M* responses to the Rorschach stimuli were associated with neural mirroring activity in the brain detected by the suppression of mu wave to EEG. Theoretical, clinical as well as empirical literature (see Introduction) indicate that while delivering *M* responses, the subject is likely using higher-level psychological functions related to cognitive sophistication, imagination, creativity, field independence, ego strength, cognitive processing of inner feelings, social cognition, and empathy. Mirror neurons are premotor neurons that fire not only when the subject performs an action but also when the subject observes another subject performing an action. More important, the MNS is hypothesized to facilitate the understanding of the underlying intentions, thoughts, and feelings that motivate a given action, thus providing the neural basis for understanding self and others' behaviors and states

of mind (Buccino et al., 2001; Rizzolatti et al., 2001; Umiltà et al., 2001). In our first explorative study (Giromini et al., 2010), by using a test-contrast-control experiment we found confirmation that *M* responses are associated with mirroring activity. This result indicates that even in the absence of actual moving stimuli, and in the presence of static visual stimuli as the Rorschach cards, the inner feeling of movement is sufficient to trigger MNS activity when the intention of the action is "projected" onto the perceived human figure. As this first study used only 4 Rorschach cards with the higher and the lower frequency of *M* responses, it was replicated in our second study (Pineda et al., 2011) where the Rorschach test was administered closer to the standard procedure and with more appropriate experimental conditions (larger sample size, control for baseline condition, longer period of EGG data collection).

In the present study we explored two specific hypotheses with the aim of providing clinicians with a stronger empirical basis for the clinical interpretation of human movement to the Rorschach test. More in detail, we aimed at establishing the discriminant validity of the association between *M* responses and mirroring activity, and at investigating the relationship between mu suppression and a number of subtypes of *M*.

In our first hypothesis, "M vs. Other Determinants", we explored whether mu wave suppression to the EEG recording – a likely index of mirroring activity – occurs uniquely when *M*s are given and not when other kinds of Rorschach-based movement responses such as animal or inanimate movements, as well as other movement-unrelated responses such as color, shading, and pure form responses. Findings show that our first hypothesis was fully confirmed. A highly significant mu suppression, with a large effect size ($\eta^2 = .17$), occurred only when subjects delivered *M* responses and not when they described movement performed by an animal or an inanimate object, objects without any movement implication, or other features of the blots, such as color, shading or its shape. For the first time, evidence for the

discriminant validity of the association between *M* responses and mirroring activity has been provided.

As predicted by our first hypothesis, the internal representation of the feeling of movement elicited by the static inkblot stimuli and expressed uniquely by the *M* responses are suggestive of the concurrent mirroring activity. This conclusion is made robust by controlling for multiple conditions. First and most important, no index of MNS activity has been observed in other kinds of Rorschach responses, regardless of whether movement was or was not involved in the response process. Second, the mu wave suppression indicated by the absence of activity in the EEG 8-13 Hz frequency band was specific to central sites of the brain corresponding to the MNS location, whereas mu suppression was not recorded at occipital sites that were used as controls. Third, the attention of subjects was controlled during the baseline condition when they were asked to engage in a continuous performance task lasting 90 s (counting the number of times the screen turned color from blue to red). Finally, a sufficient duration of EEG recording was collected which were constituted by a total of 600 s for 20 responses.

Since the origin of the test, the production of an *M* response to the Rorschach has been thought to rely on identification process: Individuals identify themselves with other human figures seen in the blot while 'simulating' the feeling of movement within themselves, as if they moved themselves (Malmgren, 2000). We propose that this self-initiated "feeling of movement", internally perceived and cognitively processed by the subjects, constitutes a powerful stimulus for MNS activity. Previous studies showed that the MNS is triggered by perceptual stimuli in which actions were explicit (moving objects in video clips) or implicit (still pictures which suggest movement) (Rizzolatti & Craighero, 2004). Conversely, our results were obtained in response to static stimuli that offer to the observer only minimal, ambiguous cues. The psychological process underlying the production of *M* responses closely

resembles that of embodied simulation. It has been proposed that the human capacity to pre-rationally make sense of actions, emotions and sensations of others depends on "embodied simulation," a functional mechanism through which the actions, emotions, or sensations we see activate our own internal representations of body states, that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Freedberg & Gallese, 2007). Based on the MNS process, Gallese (2001, 2003) speculated that this "shared manifold hypothesis of intersubjectivity" allows us to recognize other human beings who are similar to us. Accordingly, we argued (Giromini et al., 2010) that this position is supported within the social cognition field, a broad concept that refers to the cognitive and brain processes that subserve behavior in response to other individuals of the same species (Adolphs, 1999). By the fact that the specifics, content, and attributions ensconced in the M response that is the meaning made in the response, is produced by the individual, such idiographic information may very well have special relevance to the individual. Such an understanding has been assumed by Rorschach practitioners when interpreting idiosyncratic M response content (Exner, 1969; Meyer et al., 2011; Piotrowski, 1957).

Although the effect size for *M* and mu suppression was considerably larger compared to effect sizes for mu suppression and other Rorschach determinants, two cautions should be expressed. First, the sample size was rather small (N = 24), and for some variables we only had a few observations per subject, as indicated by the low mean values reported in table 1. This is certainly a limiting factor for this study, in terms of both power and sensitivity of these analyses, so that our findings need to be confirmed on larger samples. Second, responses involving human beings who were not seen in movement (Non-*M H* Contents; Table 1, Category 2) showed a medium effect size (η^2 = .06), and approached statistical significance (p = .055). According to Exner (2003) the production of human content

responses *per se* (i.e., regardless of the presence or absence of movement) to the Rorschach provides information about a facet of social competence related to the subject's interest in people, as "persons with considerable interest in others, for any of a variety of reasons, typically give several human content responses" (Exner, 2003, p.497). Future studies, with larger samples, might therefore investigate a possible association of mirroring activity and human contents to the Rorschach regardless of movement involvement.

In our second hypothesis, "Subtypes of M," we explored whether mu wave suppression occurs more frequently to Rorschach codes thought to be more closely related to social cognition (adequately perceived whole human beings in active movement, i.e. *M* responses associated with ordinary Form Quality or *FQo*, active movement or *Ma*, and whole human figures or Pure *H*) rather than human movements more related to poor social cognition (i.e., *M* responses associated with distorted or infrequent Form Quality or *FQ-/FQu*, passive movement or *Mp*, and partial or fictional human figures or non-Pure *H*). Findings show that our second hypothesis was confirmed in part.

As expected, among the various specifications of human movement, active movement (*Ma*) was found to significantly associate with greater mu suppression compared to passive movement (*Mp*). The raw mean value of -.30 observed for *Ma* in our sample was the highest mu suppression value among all the responses we investigated (see Table 3). In the CS, the active-to-passive *M* ratio is worthy of clinical attention when *Mp* is greater than *Ma*, reflecting a passive and possibly dependent interpersonal style and the subject is "more likely to take flight into passive forms of fantasy as a defensive maneuvers, and [is] less likely to initiate decisions or behaviors if the alternative that others will do so is available" (Exner, 2003, p.439). As a consequence, because *Mp* is less frequent and reflects a more problematic and less desirable type of response than *Ma*, *Mp* generally receives greater interpretive attention than *Ma* in the clinical context. Our findings suggest that the relevance of *Ma*

responses may be underestimated among clinicians. Indeed, according to our data, *Ma* responses might actually reveal important information in terms of social cognition and social competence resources because seeing active human movements in the Rorschach cards might likely trigger mirroring activity and therefore indicate more ability to identify with other human beings and competence in social cognition.

Another prediction of this study concerned the form quality of the *M* response. The presence of good quality *M*s is, in fact, a positive prognostic indicator, and *M* responses associated with distorted form quality may reflect disturbed thinking (Exner, 2003). Accordingly, we expected higher mu suppression for adequate vs. distorted perceptions of human beings in movement. Instead, no differences were found. However, it should be pointed out that – although non-significant – the observed mu suppression for *M/FQo* was higher than mu suppression for *M/FQ-/FQu*. Given that the effect size of this main effect was medium (η^2 = .08) and that the sample size of this analysis was small (N = 11), with a greater sample size such a difference might be significant. Thus, more research is needed to disentangle whether adequately perceived human movement (*M/FQo*) are more associated with mu suppression than distorted-unusually perceived human movement (*M/FQ-/FQu*).

Finally, we anticipated that mu suppression for *M* associated with whole human figures (pure *H*) would be greater than mu suppression for *M* associated with non-whole human figures (non-pure *H*). Pure *H* is the only content coding category used for responses that include whole real people whereas human details and human-like figures refer to partial human body and fictional people. Whole human contents are therefore more common among individuals whose self-image is based more on identifications with real persons while non-whole human figures are more common among those whose self-image is based more on imagination or internal representations that coincide less with reality. Put simply, whole human contents reflect more accurate, integrated, and complete view of people than human

details and human-like figures (Exner, 2003; Weiner, 2003). Findings do not support our second hypothesis. However, it may be worthy to note that this result may have been influenced by the fact that 18 of 31 (41.9%) *M*s with non-pure *H* consisted of "face" responses (e.g., Card VII: "faces of children talking to each other"). It has been suggested that face stimuli are processed differently than other types of visual information because of their evolutionary and interpersonal value (e.g., de Haan & Nelson, 1999; McCarthy, Puce, Gore & Allison, 1997; Meyer et al., 2011), so that they may actually reveal awareness of, or interest in, other people. Because of the very small number of subjects included in this sub-group, we were not able to run a comparison analysis to disentangle the specific role of "face" responses. This hypothesis paves the way for further Rorschach research in this direction.

Some limitations of this study that prevent generalizing the results should be mentioned. First, for some variables only a few observations per subject were available, and the sample size consisted of a small number of undergraduate students, mostly women, with a rather homogeneous cultural background and a limited age range. The results should therefore be confirmed with a larger and more heterogeneous sample. Second, this study sought to quantify within-subject differences in mu suppression related to different response processes, but did not investigate any between-subject differences, because of the limited sample size. According to power analysis, indeed, between-subject comparisons require about three times the sample size required for within-subject comparisons. Future studies with larger sample sizes, therefore, should attempt to compare different groups selected on the basis of their Rorschach profiles. For example, it will be important to test the mu suppression phenomenon among those subjects who show Mp>Ma, those who show H<[(H)+Hd+(Hd)], and so forth. Third, in this study we investigated the impact of form quality on mu suppression by comparing M/FQo vs. M/FQ-/FQu. That is, we combined the

M/FQ- response with the M/FQu response, because too few EEG data were available for the M/FQ- response alone. However, for theoretical reasons (Exner, 2003; Meyer et al., 2011), a better test of this contrast would probably be to look at the M/FQ- response alone vs. M/FQu or M/FQo. Future studies should attempt to further investigate this issue. Similarly, future research should also evaluate the infrequent but clinically relevant good Ms embedded in pathological responses (Level 2 Cognitive Special Scores, ALOG or CONTAM), which were not analyzed in this study, again due to the limited amount of available EEG data. Fourth, participants were not screened for the presence of psychopathology or influencing level of psychological distress. Evidence suggests that the number of *M* responses is associated to specific personality functioning such as alexithymia (Porcelli & Meyer, 2002; Porcelli & Mihura, 2010) and the quality of *M*s to psychopathology (Mihura, Meyer, Dumitrascu, & Bombel, in press) and DSM-IV-defined personality disorders (Huprich, 2006). The association of *M* and MNS activity should be further investigated on clinical samples to evaluate the specific role played by psychopathological syndromes. Finally, although mu wave suppression is considered a valid index of mirroring activity (Cochin et al., 1998; Muthukumaraswamy & Johnson, 2004; Oberman, McCleery et al., 2007; Oberman, Pineda et al., 2007; Pineda et al., 2000; Pizzamiglio et al., 2005; Rizzolatti et al., 2001), owing to the low spatial resolution of EEG it is difficult to differentiate between activity selective to the premotor MNS and activity in other regions that are part of a larger action observation/execution network that may modulate the activity in the premotor MNS (Muthukumaraswamy & Johnson, 2004; Muthukumaraswamy et al., 2004). Further investigations with higher-spatial-resolution techniques, such as functional magnetic resonance imaging and high-resolution EEG, may be able to dissociate between these two sources of activation.

In conclusion, for the first time to our knowledge, this and our previous investigations (Giromini et al., 2010; Pineda et al., 2011) show that Rorschach *M* responses are based on a neurobiological ground indexed by the activation of mirror neurons. This overall result is fully consistent with the century-long tradition of the Rorschach theoretical, as well as empirical, literature. Two main conclusions can be drawn from these findings. First, mu suppression specifically occurred for human movement responses (*M*) and did not occur for any Rorschach responses involving movement (*FM* and *m*). Thus this type of suppression seems to underlie MNS activation, suggesting a neurobiological basis for the clinical interpretation of *M* determinant related to empathy and social cognition, supporting theoretical speculations and clinical data. Second, future research should explore further and address the likely clinical utility of active human movement (*Ma*) as the present study suggests it is more closely related to the MNS activity than other movement-related Rorschach scores. Also, from a broader perspective, one might speculate that the view of *M* as index of higher psychological functioning and social cognition is consistent with historical and contemporary theoretical models. For example, Piotrowski (1957) speculated that *M* indicates basic 'role-in-life', deeply embedded in the subject's ego, to assume stable attitudes when relating to significant others. In his view, *M* is not a definite self-image but stems from the integration of past and current representations of self and others that are implicit in the subject's behavior as potential underlying correlates. Thus, acting inconsistently with one's conception of role causes anxiety and distress. Contemporary models of mind highlight the close link between individual and relational activity within the brain. For example, Damasio (1999) referred to embodied cognition as the ability of the brain in simulation mode to reproduce actual somatic states when emotions are induced not by observing others but also by only feeling them in mind, and Fonagy, Gergely, Jurist, and Target (2002) to the construct of mentalization as the individual ability to make and use symbolic representations of one's

own and the other's mental states. Given the importance of these constructs in clinical practice and psychological treatment (Allen, Fonagy, & Bateman, 2008), the association of *M* to the mirroring activity may shed new lights in Rorschach clinical interpretation.

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Table 1.

Codes Included in the Analysis of Hypothesis 1 and their Descriptive Statistics

Category & Label	***Description***	***Code***	***Min***	***Max***	***M***	***SD***
1) Human movement responses	Any human movement [*M*]	*M*	1	9	4.3	2.2
2) Non-moving human content responses	Whole [*H*], partial [*Hd*], or human-like [*(H), (Hd)*] figures that are seen as non-moving	Non-*M* *H* Contents	0	7	2.8	1.8
3) Non-human movement responses	Animal movement determinant [*FM*] or inanimate movement determinant [*m*]	*FM/m*	1	9	4.9	2.3
4) Other Rorschach determinants	Any color determinant [*FC, CF, pure C*]	*C*	0	14	4.7	3.6
	Any shading determinant including diffuse shading [*FY, YF, Y*], texture [*FT, TF, T*], tri-dimensional [*FV, VF, V, FD*], and achromatic color [*FC', C'F, C'*]	Shading	0	6	3.0	1.6
	Responses based exclusively on the shape of the blot [*F*]	*F*	1	15	7.3	2.9

Note: In the Comprehensive System, animals that are seen in non species-specific kind of movement are coded *M* as for the determinant (implying the use of fantasizing activity) and *A* as content (e.g., "an ant dancing rock 'n' roll")

Table 2.

Codes Included in the Analysis of Hypothesis 2 and their Descriptive Statistics

Optimal Type of M						**Non-Optimal Type of M**					
Label & Code	***Description***	***Min***	***Max***	***M***	***SD***	***Label & Code***	***Description***	***Min***	***Max***	***M***	***SD***
Adequate perception of human movement (*M/FQo*)	Human movement [*M*] associated to Form Quality ordinary [*FQo*]	1	8	3.4	1.9	Distorted or unusual perception of human movement (*M/FQ-/FQu*)	Human movement [*M*] associated to Form Quality minus [*FQ-*] or Form Quality unusual [*FQu*]	0	4	.9	1.1
Active human movement (*Ma*)	Human movement [*M*] associated to activity [*Ma*]	0	5	2.2	1.6	Passive human movement (*Mp*)	Human movement [*M*] associated to passivity [*Mp*]	0	8	2.1	1.7
Human movement associated with whole human figures (*M/PureH*)	Human movement [*M*] associated to whole human figure [*H*]	0	7	2.9	1.9	Human movement associated with non whole human figures (*M/NonPureH*)	Human movement [*M*] associated to content categories of animals [*A*], human details [*Hd*], and human-like figures or details [*(H), (Hd)*]	0	3	1.3	1.1

Table 3.

Main Effect on Mu Suppression for the Rorschach Responses Under Investigation

		Mu Suppression for Presence of Response		Mu Suppression for Absence of Response		Main Effect for Response (Presence vs. Absence)			
Hypothesis 1 (*M* vs. Other Determinants)	***N***	***M***	***SE***	***M***	***SE***	***F***	***df***	***p***	***η²***
Human Movement Responses (*M*)	24	-.24	.05	-.17	.05	18.76	1,23	.000	.17
Non-Moving Human Contents (Non-*M H* Contents) [a]	23	-.19	.06	-.15	.05	4.12	1,22	.055	.06
Non-Human Movement Responses (*FM/m*)	24	-.17	.06	-.18	.05	.13	1,23	.718	<.01
Color Responses (*C*)	22	-.17	.06	-.16	.05	.01	1,21	.930	<.01
Shading Responses (Shading)	23	-.16	.06	-.19	.05	2.12	1,22	.160	.03
Pure Form Responses (*F*)	24	-.17	.07	-.19	.05	.86	1,23	.362	.01
Hypothesis 2 (Subtypes of *M*) [b]	***N***	***M***	***SE***	***M***	***SE***	***F***	***df***	***p***	***η²***
Adequately (*M/FQo*) perceived *M* responses	17	-.20	.06	-.13	.07	1.95	1,10	.193	.08
Active (*Ma*) *M* responses	18	-.30	.07	-.21	.05	7.27	1,17	.015	.13
M associated with whole human figures (*M/PureH*)	11	-.25	.06	-.28	.05	.30	1,16	.593	.01

Notes: [a] Given that it is likely that *M* responses occur along with human contents, to avoid confounds this contrast was tested after excluding all *M* responses from the analysis; [b] Only *M* responses are considered for this analysis; absence of *M/FQo, Ma*, and *M/PureH* responses, therefore, indicates – respectively – presence of *M/FQ-/FQu, Mp*, and *M/NonPureH* responses.

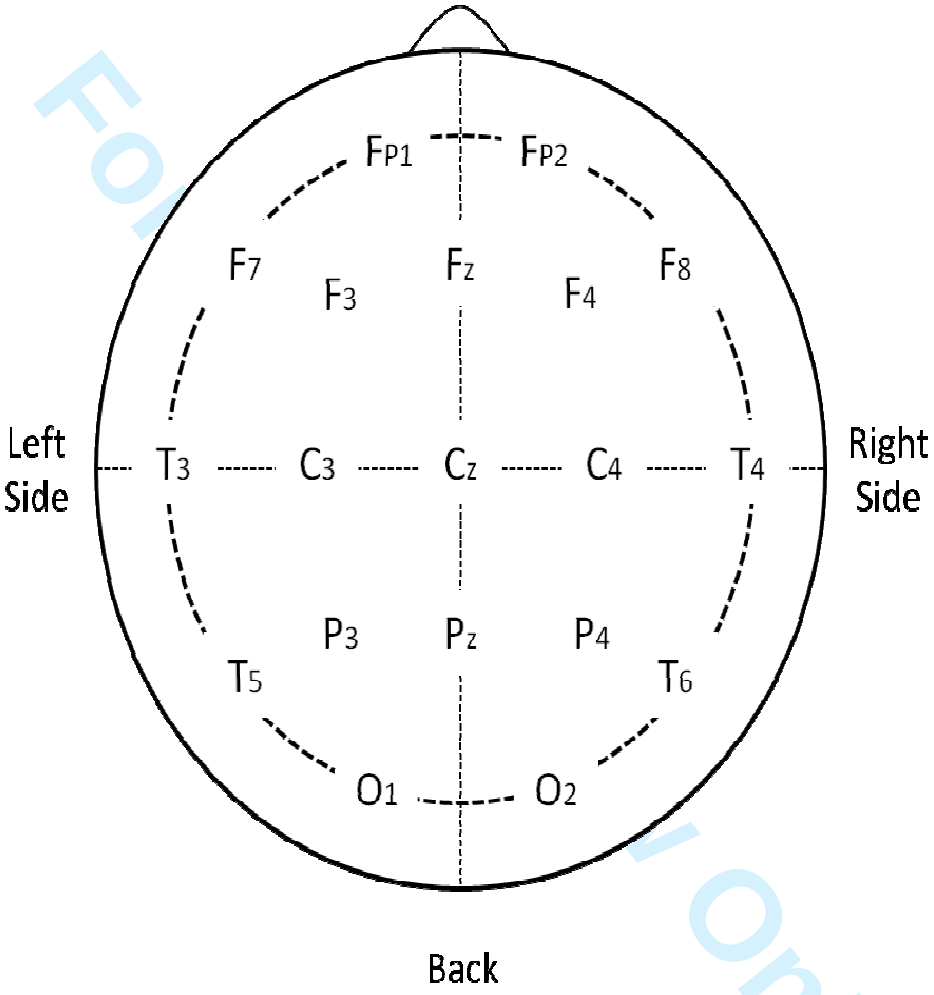
Figure Caption

Figure 1.

Map of the EEG scalp locations.

Note: According to the International 10-20 system method, each site has a letter to identify the lobe and a number to identify the hemisphere location. As for the letters, F stands for frontal, T for temporal, P for parietal, and O for occipital. Although there exits no central lobe, a letter C is also used, for identification purpose, and stands for central. As for the numbers, odd numbers refer to locations in the left hemisphere, and even numbers refer to locations in the right hemisphere; the letter z stands for zero and refers to the midline.

Figure 1



Footnotes

[1]Although the word 'kinesthesia' in the Rorschach literature is often adopted with the original meaning given by Rorschach, it should be noted that this term may be labeled within the neurocognitive science field as kinesthetic identification, mimicking or simulating.

[2]The term "social cognition" is often used interchangeably with terms such as "theory of mind" and "social perception." Originally coined by Premack and Woodruff in 1978, theory of mind involves the ability to understand and identify others' mental states. In a related way social perception, introduced by Brunner in 1947, refers to forming impressions and making inferences about other people's intentions. Here, we broadly refer to "social cognition" as the cognitive and brain processes that subserve behavior with other people (Adolphs, 1999). From this perspective, it subsumes both theory of mind and social perception.

[3] We combined the M/FQ- response with the M/FQu response, because too few EEG data were available for the M with FQ- response alone. Indeed, only six individuals produced M/FQ- responses, and three of them produced only one M/FQ-